

Swift Observations of GRB 130925A

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1. Introduction

At 04:11:24 UT, the Swift Burst Alert Telescope (BAT) triggered and located GRB 130925A (trigger=571830) (Lien *et al.* GCN Circ. 15246). Swift slewed immediately to the burst. At the time of the trigger, the initial BAT position was 134° from the Sun (9.4 hours West) and 53° from the 69%-illuminated Moon. **Table 1** contains the best reported positions from Swift, and the latest XRT position can be viewed at http://www.swift.ac.uk/xrt_positions.

Sudilovsky *et al.* (GCN Circ. 15247) reported the position from GROND for the optical afterglow of this GRB. Vreeswijk *et al.* (GCN Circ. 15249) determined a redshift of 0.347 from VLT, and Sudilovsky *et al.* (GCN Circ. 15250) determined a redshift of 0.35 from VLT. **Table 2** is a summary of GCN Circulars about this GRB from observatories other than Swift.

The early-time light curve of this burst shows similarity to the tidal disruption event Swift J1644+57 (Burrows *et al.* GCN Circ 15253; Jenke *et al.* GCN Circ 15261). However, late-time XRT light curve and follow-up observations show that this event is likely to be a GRB (e.g., Castro-Tirado *et al.* GCN Circ 15299; Tanvir *et al.* GCN Circ 15489).

The XRT observations lasted until March 4, 2014. More complete analyses for this GRB can be found in papers Hou *et al.* 2014 (ApJ, 781L, 19H), Zhao *et al.* 2014 (arXiv1403.3825), Bellm *et al.* 2014 (ApJ, 748L, 19B), and Evans *et al.* 2014 (arXiv1403.4079).

Standard analysis products for this burst are available at http://gcn.gsfc.nasa.gov/swift_gnd_ana.html.

2. BAT Observations and Analysis

As reported by Markwardt *et al.* (GCN Circ. 15257), the BAT ground-calculated position is RA, Dec = 41.186, -26.146 deg which is RA(J2000) = $02^{\text{h}}44^{\text{m}}44.5^{\text{s}}$ Dec(J2000) = $-26^{\circ}08'47.4''$ with an uncertainty of 1.0 arcmin, (radius, sys+stat, 90% containment). The partial coding was 9%.

The mask-weighted light curve (**Figure 1**) covers only a small part of this exceptionally long GRB. As reported by the Fermi-GBM team (Fitzpatrick, GCN Circ. # 15255) the event may have begun 17 minutes prior to the BAT trigger, and the source was still detected in BAT at T+2 hours. Thus we cannot estimate a T_{90} . The extended BAT light curve made from survey data is shown in **Figure 2**. There were multiple peaks and several late-time flares.

The time-averaged spectrum from T-59 to T+903 s is best fit by a power law with an exponential cutoff. This fit gives a photon index 1.85 ± 0.14 , and E_{peak} of 33.4 ± 20.0 keV (χ^2 38.18 for 56 d.o.f.). For this model the total fluence in the 15-150 keV band is $4.1 \pm 0.1 \times 10^{-5}$ erg cm^{-2} and the 1-s peak flux measured from T-35.64 s in the 15-150 keV band is 7.3 ± 0.6 ph $\text{cm}^{-2} \text{s}^{-1}$. This fluence is larger than that of 99.3% of the long GRBs in the Second BAT GRB Catalog (Sakamoto *et al.* 2011). A fit to a simple power law gives a photon index of 2.09 ± 0.04 (χ^2 45.62 for 57 d.o.f.). The flares at T+4950 and T+7100 seconds have photon indices in simple power-law fits of 2.19 ± 0.36 and 2.34 ± 0.28 respectively. All the quoted errors are at the 90% confidence level.

The results of the batgrbproduct analysis are available at http://gcn.gsfc.nasa.gov/notices_s/571830/BA/.

3. XRT Observations and Analysis

Analysis of the initial XRT data was reported by Evans *et al.* (GCN Circ. 15254). The XRT team has analysed 260 ks of XRT data for GRB 130925A, from 137 s to 4440.2 ks after the BAT trigger. The data comprise 3.3 ks in Windowed Timing (WT) mode (the first 9 s were taken while Swift was slewing) with the remainder in Photon Counting (PC) mode. The enhanced XRT position for this burst was given by Evans *et al.* (GCN Circ. 15251; see **Table 1**).

The late-time light curve (**Figure 3**) (from T0+1.8 ks) can be modelled with an initial power-law decay with an index of $\alpha=0.820 (+0.029, -0.032)$, followed by a break at T+300 ks to an α of 1.32 ± 0.04 .

A spectrum formed from the WT mode data can be fitted with an absorbed power-law with a photon spectral index of 1.733 ± 0.019 . The best-fitting absorption column is $7.01 \pm 0.14 \times 10^{21} \text{ cm}^{-2}$, in excess of the Galactic value of $1.7 \times 10^{20} \text{ cm}^{-2}$ (Kalberla *et al.* 2005). The PC mode spectrum has a photon index of $2.69 (+0.13, -0.12)$ and a best-fitting absorption column of $10.0 \pm 0.8 \times 10^{21} \text{ cm}^{-2}$. The counts to observed (unabsorbed) 0.3-10 keV flux conversion factor deduced from this spectrum is $4.1 \times 10^{-11} (1.7 \times 10^{-10}) \text{ erg cm}^{-2} \text{ count}^{-1}$.

A summary of the PC-mode spectrum is thus:

Total column: $10.0 \pm 0.8 \times 10^{21} \text{ cm}^{-2}$

Galactic foreground: $1.7 \times 10^{20} \text{ cm}^{-2}$

Excess significance: 20.3σ

Photon index: $2.69 (+0.13, -0.12)$

The results of the XRT team automatic analysis are available at http://www.swift.ac.uk/xrt_products/00571830.

4. UVOT Observations and Analysis

The Swift/UVOT began settled observations of the field of GRB 130925A 157 s after the BAT trigger (Lien *et al.* 2013, GCN Circ. 15246) (Holland and Lien GCN Circ. 15266). UVOT did not detect any new source consistent with the GROND afterglow position (Sudilovsky *et al.* 2013, GCN Circ. 15247) in any of the UVOT exposures. **Table 3** gives preliminary magnitudes using the UVOT photometric system (Breeveld *et al.* 2011, AIP Conf. Proc., 1358, 373). No correction has been made for the expected extinction in the Milky Way corresponding to a reddening of E_{B-V} of 0.02 mag. in the direction of the GRB (Schlegel *et al.* 1998).

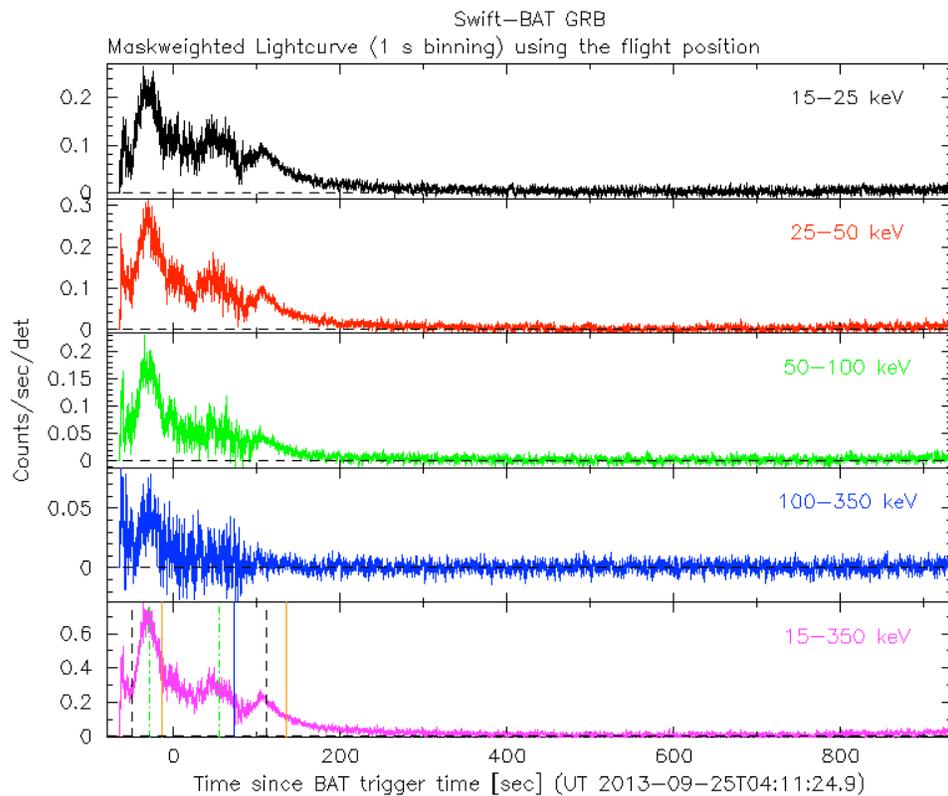


Figure 1. The BAT mask-weighted light curve in the four individual and total energy bands. The units are counts s^{-1} illuminated-detector $^{-1}$.

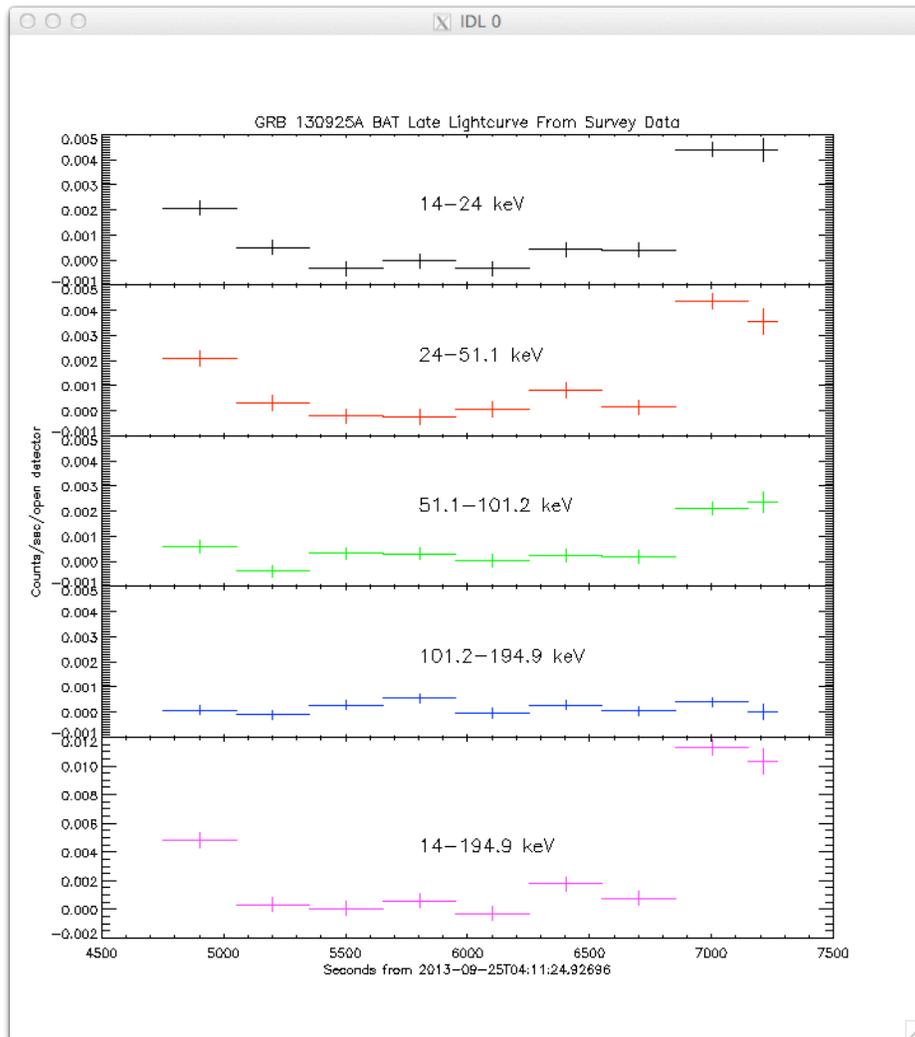


Figure 2. The BAT mask-weighted light curve from survey data (made by Jay Cummings).

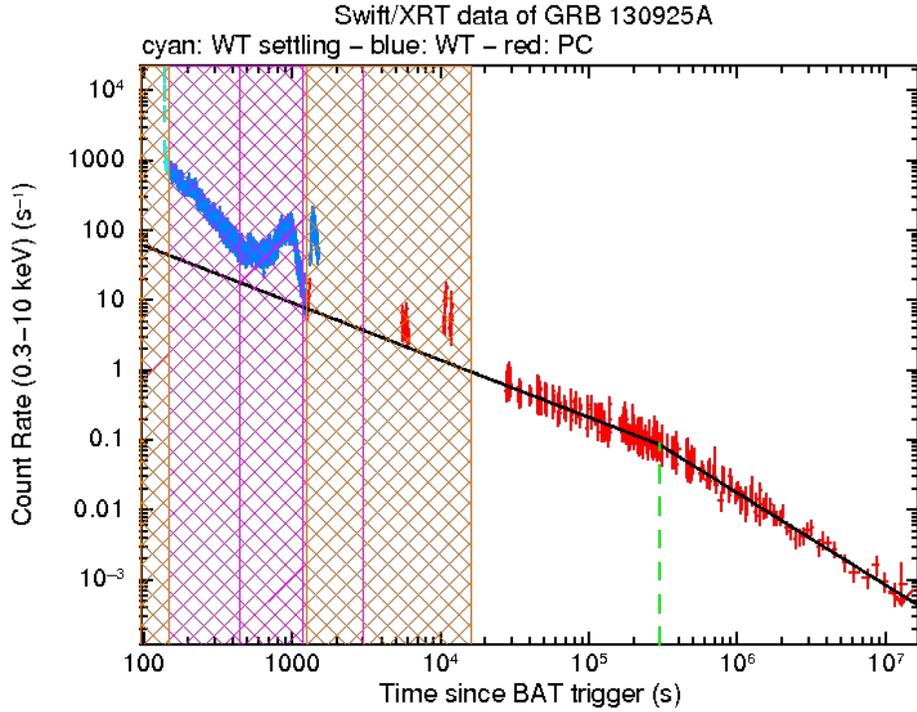


Figure 3. The XRT light curve. Any data from a cross-hatched region are not included in the fit.

RA (J2000)	Dec (J2000)	Error	Note	Reference
02 ^h 44 ^m 42.97 ^s	-26°09'11.5"	1.4"	XRT-final	UKSSDC
02 ^h 44 ^m 42.91 ^s	-26°09'10.8"	1.6"	XRT-enhanced	Evans <i>et al.</i> GCN Circ. 15251
02 ^h 44 ^m 44.5 ^s	-26°08'47.4"	1.0'	BAT-refined	Markwardt <i>et al.</i> GCN Circ. 15257

Table 1. Positions from the Swift instruments.

Band	Authors	GCN Circ.	Subject	Observatory	Notes
Optical	Sudilovsky <i>et al.</i>	15247	GROND afterglow candidate	GROND	detection
Optical	Vreeswijk <i>et al.</i>	15249	VLT/UVES observations	VLT	
Optical	Sudilovsky <i>et al.</i>	15250	VLT/X-shooter redshift	VLT	redshift
Optical	Klotz <i>et al.</i>	15252	TAROT La Silla observatory optical observations	TAROT	
Optical	Butler <i>et al.</i>	15258	RATIR Optical and NIR Observations	RATIR	detection
Optical	Butler <i>et al.</i>	15262	Continued RATIR Optical and NIR Observations	RATIR	detection
Optical	Volnova <i>et al.</i>	15263	optical upper limit	Gissar Astro. Obs.	upper limits

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Optical	Tanvir <i>et al.</i>	15489	HST imaging	HST	
Radio	Zauderer <i>et al.</i>	15264	sub-mm non-detection with SMA	SMA	
Radio	Castro-Tirado <i>et al.</i>	15299	Sw J0244-2609: mm observations at PdBI	PdBI	
Radio	Zauderer <i>et al.</i>	15301	3mm observations with CARMA	CARMA	
X-ray	Suzuki <i>et al.</i>	15248	MAXI/GSC detection	MAXI	detection
X-ray	Gelbord	15256	Historical non-detection from Rosat-HRI	ROSAT	
Gamma-ray	Fitzpatrick	15255	Fermi GBM detection of GRB 130925A and a possible precursor	Fermi GBM	possible detection
Gamma-ray	Savchenko <i>et al.</i>	15259	Observation of possible GRB/TDE 130925A by INTEGRAL/SPI-ACS: three activity episodes	INTEGRAL	light curve
Gamma-ray	Golenetskii <i>et al.</i>	15260	Konus-Wind observation	Konus-Wind	$E_{\text{peak}} = 181 \pm 10$ keV
Gamma-ray	Jenke	15261	Fermi GBM Detection	Fermi GBM	$E_{\text{peak}} = 107 \pm 3$ keV
Gamma-ray	Kocevski <i>et al.</i>	15268	Fermi LAT Upper Limits on GRB 130925A	Fermi LAT	upper limits
Gamma-ray	Hurley <i>et al.</i>	15278	IPN Observations	IPN	

Table 2. Summary of GCN Circulars from other observatories sorted by band and then circular number.

Filter	T _{start}	T _{stop}	Exposure	Mag
white _{FC}	157	306	147	>21.4
u _{FC}	315	564	246	>20.6
v	645	7269	381	>20.0
b	571	6121	170	>20.6
u	719	5983	274	>20.4
uvw1	5579	11,956	701	>21.1
uvm2	5374	11,436	1082	>21.2
uvw2	4964	7136	393	>20.7
white	595	6929	618	>22.0

Table 3. UVOT observations reported by Holland and Lien (GCN Circ. 15266). The start and stop times of the exposures are given in seconds since the BAT trigger. The preliminary 3- σ upper limits are given. No correction has been made for extinction in the Milky Way.

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